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ELEVENTH QUARTERLY PROGRESS REPORT

PRODUCT ENGINEERING MEASURES

SOLID STATE MICROWAVE OSCILLATORS FOR FUZES

CONTRACT NO. DAAB05-73-C-2070

1 NOVEMBER 1975 TO 1 FEBRUARY 1976

Prepared for

UNITED STATES ARMY ELECTRONICS COMMAND

PHILADELPHIA, PENSYLVANIA 19103

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OBJECT OF PROGRAM

The object of the work performed under this contract is to establish a production capability for narrow pulse TRAPATT oscillators to operate at 800 MHz and 4 GHz.

CONTRACT NO. DAAB05-73-C-2070

Prepared by

H. C. Bowers
W. R. Lane
W. H. Lockyear
C. O. G. Obah

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Work performed during the 11th quarter toward establishing a manufacturing capability for TRAPATT oscillators is described. The engineering sample and first article diodes for both 0.8 GHz and 4.0 GHz have been delivered. The test results obtained for these diodes are discussed. The engineering test sample oscillator circuits have been delivered and the test data for these oscillators is discussed. Final adjustments to the engineering sample modulators are discussed.

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FOREWORD

This project was initiated by the U.S. Army Electronics Command. The work described herein was carried out at the Hughes Aircraft Company, 3100 West Lomita Boulevard, Torrance, California, 90509. This report summarizes the development program carried out during the period 1 November 1975 through 1 February 1976.

ABSTRACT

Work performed during the eleventh quarter toward establishing a manufacturing capability for TRAPATT oscillators is described. The engineering sample and first article diodes for both 0.8 GHz and 4.0 GHz have been delivered. The test results obtained for these diodes are discussed. The engineering test sample oscillator circuits have been delivered and the test data for these oscillators is discussed. Final adjustments to the engineering sample modulators are discussed.

1.0 INTRODUCTION AND SUMMARY

The objective of work performed under this contract is to establish a manufacturing capability for narrow pulse TRAPATT oscillators to operate at 800 MHz and 4 GHz. Diodes, oscillator circuits, and bias modulators are all to be investigated.

During the past quarter the engineering sample diodes were tested to determine compliance with all specifications including those for power, frequency, efficiency, pulse shape characteristics and temperature performance. 100% of the diodes tested passed all tests to which they were subjected. There were no failures of any type. On this basis it is concluded that all diodes manufactured according to the criteria set up for these diodes will meet the above mentioned specifications. The only difficulty encountered in these tests related to the laboratory power supply used for the testing at full duty cycle. Additionally, the first article diodes in both UHF and S-Band have been tested and found to be within specification. Both the engineering samples and the first article diodes have been shipped. On the basis of the results for both engineering sample and first article diodes it is recommended that the manufacture of pilot run diodes should proceed.

Engineering test sample oscillator assemblies for both UHF and S-Band have been tested and found to perform satisfactorily. It is recommended that manufacture and assembly of pilot run oscillator and modulator assemblies should proceed.

2.0 DIODE TESTING

2.1 Summary

During the past quarter the manufacturing of all of the engineering sample and first article diodes was completed. All of these diodes were subsequently tested to the contract specifications. Without exception, the diodes were found to meet all of the specifications of the contract. A summary of those test results is given below.

2.2 Test Results for 0.8 GHz UHF Engineering Sample Diodes

A total of twenty-five UHF diodes were tested as engineering sample diodes. Twenty of these diodes were taken through the 100% test schedule called out in Hughes Test Plan TPB 128775. Five of the diodes were taken through the more extensive sample tests as called out in that test plan.

A summary of the test results for the 0.8 GHz engineering sample diodes is given in Table 1 through 6. Table 1 presents a summary of the DC characteristics of twenty of these diodes which were subjected to the low duty tests called out in Hughes Test Plan TPB 128775. In that table the specification for each DC characteristic is given along with the minimum, maximum and average value of the parameters measured for the twenty diodes. As can be seen from the table, all of the measured values lie within the specified range.

Table 2 presents the operating characteristics of the same twenty diodes. The performance of all of these diodes is well within specifications.

In particular, it should be noted that the peak power had an average value of 341.5 Watts, which is well above the required 300 Watts minimum. Likewise, the efficiency was 31.8% on the average, again well above the specified efficiency of 25% minimum. This indicates that these diodes are capable of easily passing the required specifications.

Five engineering sample diodes were submitted to more detailed testing. The DC characteristics of these diodes is given in Table 3. In Table 4 the performance characteristics of these five diodes is presented. It should be noted that in this case the duty cycle for testing is 1%. Again it can be seen that the diodes more than meet the required specifications, and in particular, yield excellent power and efficiency at the required frequencies. The wave form characteristics of the detected RF pulse are not quite as good in this case as they are in the low duty testing. It is believed that this is due to an inadequacy in the power supply modulator used for the testing. In particular, it is noted that the wave shape of the current and voltage pulses to the diode degrades at high duty with this power supply. Nevertheless, the performance is still within specification.

In addition,to the RF testing carried out on the engineering sample diodes, life tests were carried out on 5 of the diodes. The results of these tests are shown in Table 5. As can be seen neither the breakdown voltage nor reverse leakage current changed as a result of the life tests. A small change in zero volt capacitance was noted however. This is not unusual and is expected in diodes of this type. The phenomena is most likely related to mobile ions which are left on the surface of the diode after the final cleaning step. This is similar to phenomena observed in manufacture of varactor diodes. The phenomena has no effect on the RF performance of the diodes. The above mentioned 5 diodes were also tested over a temperature range of -40° to $+75^{\circ}C$. The results are shown in Table 6. In these tests the diodes were all tuned up for a power

output of 325 Watts at room temperature. As can be seen from the table, the changes in power and frequency with temperature are well within the specifications for the diode.

2.3 Test Results for 4.0 GHz Engineering Sample Diodes

A total of 25 S-Band diodes were tested as engineering sample diode. Twenty of these diodes were taken through the 100% test schedule called out in Hughes Test Plan TPB 128774. Five of the diodes were taken through the more extensive sample tests as called out in that test plan.

A summary of the test results for the 4.0 GHz engineering sample diodes is given in Tables 7 through 12. Table 7 presents a summary of the DC characteristics of twenty of these diodes which were subjected to the low duty tests called out in Hughes Test Plan TPB 128774. In that table the specification for each DC characteristic is given along with the minimum, maximum and average value of the parameters measured for the twenty diodes. As can be seen from the table, all of the measured values lie within the specified range.

Table 8 presents the operating characteristics of the same twenty diodes. The performance of all these diodes is well within the specifications.

In particular, it should be noted that the peak power had an average value of 60.6 Watts, which is well above the required 50 Watts minimum. This indicates that these diodes are capable of easily passing the required specifications.

Five engineering sample diodes were submitted to more detailed testing. The DC characteristics of these diodes is given in Table 9. In Table 10 the performance characteristics of these five diodes is presented. It should be noted that in this case the duty cycle for testing is 2%. Again it can be seen that the diodes more than meet the required specifications, and in particular, yield excellent power and efficiency at the required frequencies. The wave form characteristics of the detected RF pulse are not quite as good in this case as they are in the low duty testing. It is believed that this is due to an inadequacy in the power supply modulator used for the testing. In particular, it is noted that the wave shape of the current and voltage pulses to the diode degrades at high duty with this power supply. Nevertheless, the performance is still within specification.

In addition to the RF testing carried out on the engineering sample diodes, life tests were carried out on 5 of the diodes. The results of these tests are shown in Table 11. As can be seen, the reverse leakage current did not change as a result of the life tests. A small change in zero volt capacitance and breakdown voltage was noted however. This is not unusual and is expected in diodes of this type. The phenomena is most likely related to mobile ions which are left on the surface of the diode after the final cleaning step. This is similar to phenomena observed in the manufacture of varactor diodes. The phenomena has no effect on the RF performance of the diodes. The above mentioned 5 diodes were also tested over a temperature range of -40^{o} to $+75^{o}C$. The results are shown in Table 12. As can be seen from the table, the changes in power and frequency with temperature are well within the specifications for the diode.

2.4 Test Results for 0.8 GHz UHF First Article Diodes

A total of twenty 0.8 GHz diodes were tested as first article units. These diodes were tested per Hughes Test Plan TPB 128775. A summary of the test results for these diodes is given in Tables 13 and 14. Table 13 presents a summary of the DC characteristics of these diodes. Table 14 presents the operating characteristics of the same 20 diodes. The performance of the diodes is within specification.

Ten of these diodes were subjected to acceleration tests per Hughes Test Plan TPB 128775. All ten of these diodes survived this test and the parameter changes were within specification. Typically, neither the breakdown voltage nor the reverse leakage current changed as a result of the acceleration testing. Very slight changes in capacitance of less than 1% were noted, but this is within the measurement error of the equipment used. Two of the diodes were subjected to full temperature tests and two of the diodes to full duty cycle tests. Again, these diodes met all specifications. Results of the temperature tests were similar to those performed on the engineering sample diodes. No change in frequency and <0.5 dB change in power was observed in the temperature range of -40 to $+75^{\circ}C$.

2.5 Test Results for 4.0 GHz First Article Diodes

A total of twenty 4.0 GHz diodes were tested as first article units. These diodes were tested per Hughes Test Plan TPB 128774. A summary of the test results for these diodes is given in Tables 15 and 16. Table 15 presents a summary of the DC characteristics of these diodes. Table 16 presents the operating characteristics of the same twenty diodes. The performance of these diodes is within specification.

Ten of these diodes were subjected to acceleration tests per Hughes Test Plan TPB 128774. All ten of these diodes survived this test and the parameter changes were within specification. Typically, neither the breakdown voltage nor the reverse leakage current changed as a result of the acceleration testing. Very slight changes in capacitance of less than 1% were noted, but this is within the measurement error of the equipment used. Two of the diodes were subjected to full temperature tests and two of the diodes to full duty cycle tests. Again, these diodes met all specifications. Results of the temperature tests were similar to those performed on the engineering sample diodes. A maximum frequency change of 0.25% and a power change of <0.5 dB was observed in the temperature range of -40 to +75°C.

TABLE 1

DC CHARACTERISTICS OF TWENTY 0.8 GHz ENGINEERING SAMPLE DIODES

DESCRIPTION			MEASUREMENT		
PARAMETER	SPEC. NO.	SPECIFICATION	MINIMUM	MAXIMUM	AVERAGE
Breakdown Voltage	3.2.1	Min. 185 VDC Max. 225 VDC	205	230	216.5
Forward Voltage	3.2.2	1.5 VDC Max.	0.77	1.0	.87
Reverse Leakage Current	3.2.3	10 μA Max.	<1	<1	<1
Capacitance At Zero Volts	3.2.4	16 Min. 40 Max. (pF)	17.4	32.0	24.0

TABLE 2

PERFORMANCE CHARACTERISTICS OF TWENTY 0.8 GHz ENGINEERING SAMPLE DIODES
(Pulse Width = 200 nsec)

DESCRIPTION			MEASUREMENT		
PARAMETER	SPEC. NO.	SPECIFICATION	MINIMUM	MAXIMUM	AVERAGE
Peak Power	3.2.5	300 Watts Min.	309	423	341.5
Avg. Power	3.2.10	0.6 Watts Min.	0.62	0.85	0.68
Frequency	3.2.6	0.7 Min. 0.9 Max. (GHz)	0.730	0.895	0.80
Operating Voltage	None	None	110	150	124.5
Operating Current	None	None	8.5	9.2	8.7
Efficiency	3.2.9	25% Min.	25.1	38.7	31.8
Rise Time	3.2.11	40 nS Max.	8	20	8.75
Fall Time	3.2.12	40 nS Max.	10	25	16
Jitter	3.2.13	10 nS Max.	0	10	5.5

TABLE 3

DC CHARACTERISTICS OF FIVE 0.8 GHz FINAL ENGINEERING SAMPLE DIODES

DESCRIPTION			MEASUREMENT		
PARAMETER	SPEC. NO.	SPECIFICATION	MINIMUM	MAXIMUM	AVERAGE
Breakdown Voltage	3.2.1	Min. 185 VDC Max. 255 VDC	210	230	221
Forward Voltage	3.2.2	1.5 VDC Max.	0.81	1.0	0.9
Reverse Leakage Current	3.2.3	10 μA Max.	<1	<1	<1
Capacitance At Zero Volts	3.2.4	16 Min. 40 Max. (pF)	18.3	35	29.7

TABLE 4

PERFORMANCE CHARACTERISTICS OF FIVE 0.8 GHz FINAL ENGINEERING SAMPLE DIODES
(Pulse Width = 200 nsec, Duty Cycle = 1.0%)

DESCRIPTION			MEASUREMENT		
PARAMETER	SPEC. NO.	SPECIFICATION	MINIMUM	MAXIMUM	AVERAGE
Peak Power	3.2.5	300 Watts Min.	312	403	361.5
Avg. Power	3.2.10	0.6 Watt Min.	3.12	4.03	3.62
Frequency	3.2.6	0.7 Min. 0.9 Max. (GHz)	0.75	0.84	0.77
Operating Voltage	None	None	110	140	130
Operating Current	None	None	8.5	11	9.7
Efficiency	3.2.9	25% Min.	26.2	31.2	28.7
Rise Time	3.2.11	40 nS Max.	10	15	11
Fall Time	3.2.12	40 nS Max.	20	25	21
Jitter	3.2.13	10 nS Max.	0	10	2.6

TABLE 5

0.8 GHz DIODE LIFE TEST DATA SUMMARY

	DESCRIPTION		MEASUREMENT		
PARAMETER	SPEC. NO.	SPECIFICATION	MINIMUM	MAXIMUM	AVERAGE
Breakdown Voltage	3.2.1	Min. 185 VDC Max. 225 VDC	210	230	221
Reverse Leakage Current	3.2.3	10 μA Max.	<1	<1	<1
Capacitance At Zero Volts	3.2.4	18 Min. 38 Max. (pF)	18.2	35.0	29.68
Change in Breakdown Voltage		±4 VDC Max.	0	0	0
Change in Reverse Leakage Current		±10 μA Max.	0	0	0
Change in Capacitance		±1 pF Max.	0.1	0.7	0.3

TABLE 6

0.8 GHz DIODE ENVIRONMENTAL TEST DATA

DESCRIPTION			MEASUREMENT		
PARAMETER	SPEC. NO.	SPECIFICATION	MINIMUM	MAXIMUM	AVERAGE
Peak Power at 25°C	3.2.5	300 Watts Min.	325	325	325
Frequency at 25°C	3.2.6	0.7 Min. 0.9 Max. (GHz)	0.7	0.76	0.71
Chg. in Power at -40°C	3.4.2	3 dB Max.	0.5	1.9	0.8
Chg. in Power at +75°C	3.4.2	3 dB Max.	0.15	0.8	0.6
Chg. in Freq. at -40°C	3.4.2	5% Max.	0	0.7	0.56
Chg. in Freq. at +75°C	3.4.2	5% Max.	0	2.1	0.7

TABLE 7

DC CHARACTERISTICS OF TWENTY 4 GHz ENGINEERING SAMPLE DIODES

DESCRIPTION			MEASUREMENT		
PARAMETER	SPEC. NO.	SPECIFICATION	MINIMUM	MAXIMUM	AVERAGE
Breakdown Voltage	3.2.1	Min. 80 VDC Max. 110 VDC	88.9	96.6	91.6
Forward Voltage	3.2.2	1.7 VDC Max	0.93	1.3	1.14
Reverse Leakage Current	3.2.3	10 μA Max.	<1	<1	<1
Capacitance At Zero Volts	3.2.4	Min. 5 Max. 13 (pF)	5.0	8.2	6.4

TABLE 8

PERFORMANCE CHARACTERISTICS OF TWENTY 4 GHz ENGINEERING SAMPLE DIODES
(Pulse Width = 200 nsec, Duty Cycle = 0.2%

DESCRIPTION			MEASUREMENT		
PARAMETER	SPEC. NO.	SPECIFICATION	MINIMUM	MAXIMUM	AVERAGE
Peak Power	3.2.5	50 Watts Min.	50.0	75.0	60.61
Avg. Power	3.2.10	0.1 Watt Min.	0.1	0.15	0.12
Frequency	3.2.6	3.8 Min. 4.2 Max. (GHz)	3.95	4.05	4.02
Operating Voltage	None	None	60	74	65.9
Operating Current	None	None	5	6	5.49
Efficiency	3.2.9	15% Min.	15.2	17.9	16.7
Rise Time	3.2.11	40 nS Max.	5	15	10
Fall Time	3.2.12	40 nS Max.	5	20	17
Jitter	3.2.13	10 nS Max.	3	10	9.2

TABLE 9

DC CHARACTERISTICS OF FIVE 4 GHz FINAL ENGINEERING SAMPLE DIODES

DESCRIPTION			MEASUREMENT		
PARAMETER	SPEC. NO.	SPECIFICATION	MINIMUM	MAXIMUM	AVERAGE
Breakdown Voltage	3.2.1	Min. 80 VDC Max. 110 VDC	92.1	95.1	93.6
Forward Voltage	3.2.2	1.7 VDC Max.	0.97	1.4	1.1
Reverse Leakage Current	3.2.3	10 μA Max.	<1	<1	<1
Capacitance At Zero Volts	3.2.4	5 Min. 13 Max. (pF)	5.9	8.9	7.0

TABLE 10

PERFORMANCE CHARACTERISTICS OF FIVE 4 GHz FINAL ENGINEERING SAMPLE DIODES
(Pulse Width = 200 nsec, Duty Cycle = 2.0%)

DESCRIPTION			MEASUREMENT		
PARAMETER	SPEC. NO.	SPECIFICATION	MINIMUM	MAXIMUM	AVERAGE
Peak Power	3.2.5	50 Watts Min.	50	66	56.8
Avg. Power	3.2.10	0.1 Watt Min.	1.0	1.32	1.14
Frequency	3.2.6	3.8 Min. 4.2 Max. (GHz)	3.97	4.08	4.0
Operating Voltage	None	None	67	74	71
Operating Current	None	None	5	5	5
Efficiency	3.2.9	15% Min.	15	18	16
Rise Time	3.2.11	40 nS Max.	10	10	10
Fall Time	3.2.12	40 nS Max.	15	20	17
Jitter	3.2.13	10 nS Max.	10	10	10

TABLE 11

4.0 GHz DIODE LIFE TEST DATA SUMMARY

DESCRIPTION			MEASUREMENT		
PARAMETER	SPEC. NO.	SPECIFICATION	MINIMUM	MAXIMUM	AVERAGE
Breakdown Voltage	3.2.1	Min. 80 VDC Max. 110 VDC	92.1	95.1	93.6
Reverse Leakage Current	3.2.2	10 µA Max.	<1	<1	<1
Capacitance At Zero Volts	3.2.4	Min. 5 Max. 15 (pF)	6.4	8.9	7.0
Change in Breakdown Voltage		±4 VDC	-1.2	-0.4	-0.78
Change in Reverse Leakage Current		±10 A Max.	0	1	0.2
Change in Capacitance		±1 pF Max.	-0.1	+0.2	+0.12

TABLE 12

4.0 GHz DIODE ENVIRONMENTAL TEST DATA

DESCRIPTION			MEASUREMENT		
PARAMETER	SPEC. NO.	SPECIFICATION	MINIMUM	MAXIMUM	AVERAGE
Peak Power at $25^{\circ}C$	3.2.5	50 Watts Min.	50	58.6	55.5
Frequency at $25^{\circ}C$	3.2.6	3.8 Min. 4.2 Max. (GHz)	3.94	4.07	4.0
Change in Pwr at $-110^{\circ}C$	3.4.2	3 dB Max.	0.0	1.1	0.6
Change in Pwr at $+75^{\circ}C$	3.4.2	3 dB Max.	0.0	1.1	0.4
Change in Freq at $-40^{\circ}C$	3.4.2	5% Max.	0.0	0.25	0.10
Change in Freq at $+75^{\circ}C$	3.4.2	5% Max.	0.0	0.74	0.15

TABLE 13

DC CHARACTERISTICS OF TWENTY 0.8 GHz ENGINEERING SAMPLE DIODES

DESCRIPTION			MEASUREMENT		
PARAMETER	SPEC. NO.	SPECIFICATION	MINIMUM	MAXIMUM	AVERAGE
Breakdown Voltage	3.2.1	Min. 185 VDC Max. 225 VDC	185	220	209
Forward Voltage	3.2.2	1.5 VDC Max.	.80	1.0	.893
Reverse Leakage Current	3.2.3	10 μA Max.	<1	1.5	<1
Capacitance At Zero Volts	3.2.4	16 Min. 40 Max. (pF)	23.1	31.7	26.8

TABLE 14

PERFORMANCE CHARACTERISTICS OF TWENTY 0.8 GHz ENGINEERING SAMPLE DIODES
(Pulse Width = 200 nsec)

DESCRIPTION			MEASUREMENT		
PARAMETER	SPEC. NO.	SPECIFICATION	MINIMUM	MAXIMUM	AVERAGE
Peak Power	3.2.5	300 Watts Min.	307	389	335
Avg. Power	3.2.10	0.6 Watts Min.	.614	.778	.670
Frequency	3.2.6	0.7 Min. 0.9 Max. (GHz)	.700	.900	.793
Operating Voltage	None	None	110	130	118
Operating Current	None	None	8.8	10	9.5
Efficiency	3.2.9	25% Min.	27	34	29.89
Rise Time	3.2.11	40 nS Max.	3	20	8.9
Fall Time	3.2.12	40 nS Max.	10	30	15.6
Jitter	3.2.13	10 nS Max.	0	10	5.2

TABLE 15

DC CHARACTERISTICS OF TWENTY 4 GHz ENGINEERING SAMPLE DIODES

DESCRIPTION			MEASUREMENT		
PARAMETER	SPEC. NO.	SPECIFICATION	MINIMUM	MAXIMUM	AVERAGE
Breakdown Voltage	3.2.1	Min. 80 VDC Max. 110 VDC	82.0	95.9	91.3
Forward Voltage	3.2.2	1.7 VDC Max.	.88	1.3	1.06
Reverse Leakage Current	3.2.3	10 μA Max.	<1	10	<1
Capacitance At Zero Volts	3.2.4	Min. 5 Max. 13 (pF)	5.8	7.9	6.86

TABLE 16

PERFORMANCE CHARACTERISTICS OF TWENTY 4 GHz ENGINEERING SAMPLE DIODES
(Pulse Width = 200 nsec, Duty Cycle = 0.2%)

DESCRIPTION			MEASUREMENT		
PARAMETER	SPEC. NO.	SPECIFICATION	MINIMUM	MAXIMUM	AVERAGE
Peak Power	3.2.5	50 Watts Min.	50	72	64
Avg. Power	3.2.10	0.1 Watt Min.	.100	.144	.128
Frequency	3.2.6	3.8 Min. 4.2 Max. (GHz)	3.98	4.20	4.09
Operating Voltage	None	None	58	70	65
Operating Current	None	None	5	7	5.9
Efficiency	3.2.9	15% Min.	15	20	16.7
Rise Time	3.2.11	40 nS Max.	10	15	11.9
Fall Time	3.2.12	40 nS Max.	8	20	14.6
Jitter	3.2.13	10 nS Max.	5	10	9.6

3.0 RF CIRCUITS

3.1 UHF Oscillator Circuit Engineering Samples

Two 0.8 GHz engineering sample circuit assemblies were prepared for delivery on this contract. These are shown in Figure 1. The circuits are essentially the same with the exception of the manner in which the diodes are mounted. Both circuits are of the lumped element type with the RF circuits on a printed circuit card assembly and the bias circuit in lumped component form. In the circuit shown in Figure 1a the diode is mounted in the base plate and comes up through a hole in the circuit board. In this case the conductor line is soldered to the diode cap. In the circuit shown in Figure 1b the diode is mounted in the side of the circuit. It contacts a conductor tab on the circuit by means of pressure with no solder being required. A detailed assembly drawing of the base mounted diode circuit was furnished in the Tenth Quarterly Report.

3.1.1 Discussion of Test Results

The circuits described above were assembled and tuned up in such a way as to yield nominally 300 Watts of RF power at 0.8 GHz in a 200 nanosecond pulse and 1% duty cycle. The remainder of the pertinent data for these circuits is given in the Data Sheets on pages 20 and 21. It was found that although both circuits yielded the required power and efficiency at high duty cycle, a significant difference was observed in the performance with respect to the detected RF waveform. In particular, it was found that the jitter in the circuit with the side mounted diode was substantially worse than that of the circuit with the diode mounted in the base plate. It is believed that this is due to the larger inductance associated with the diode mounting in the side mounted circuit. As a result of these tests, it is felt that it is necessary to mount the diode in the base plate underneath the circuit board to obtain optimum jitter.

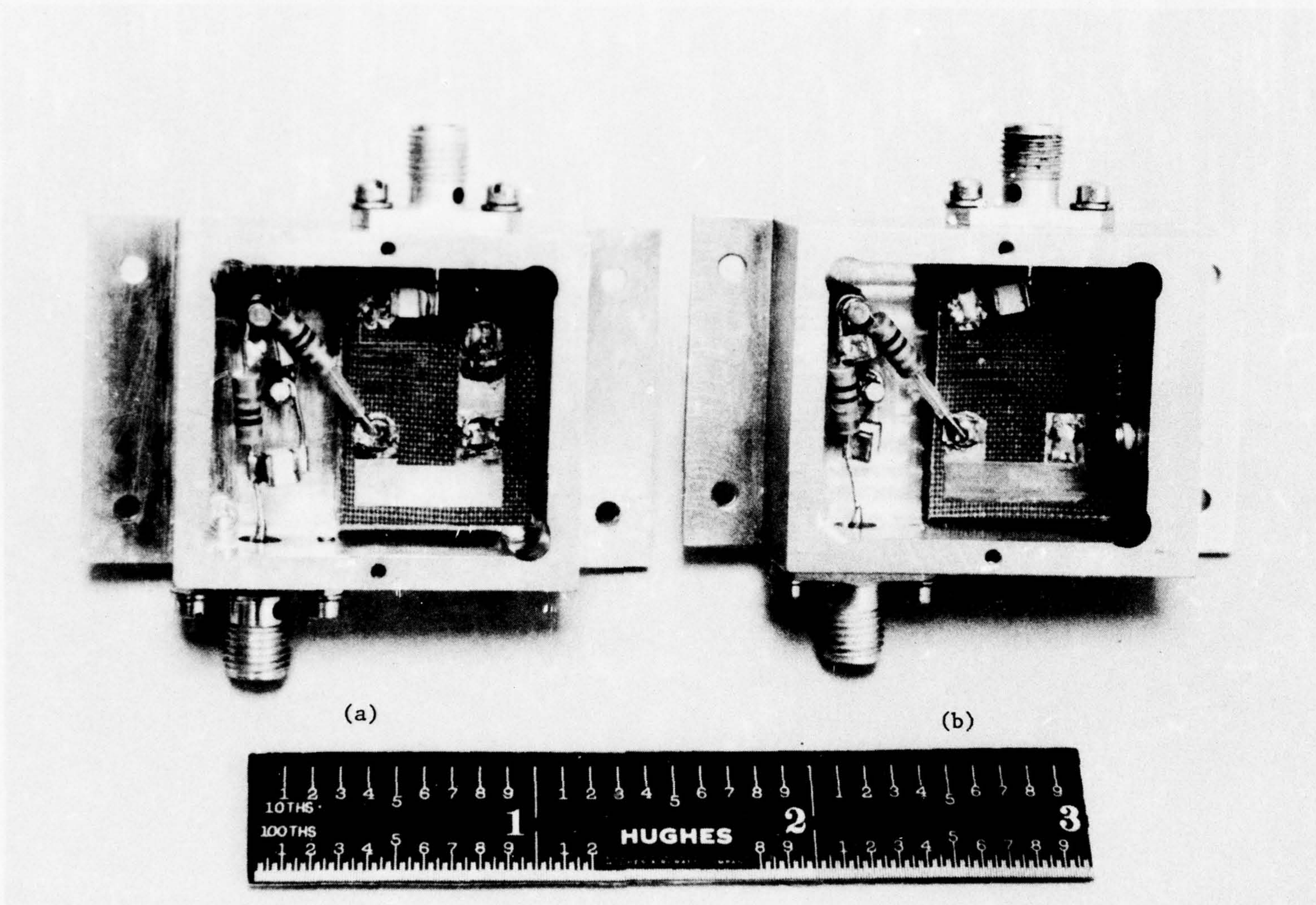


Figure 1. UHF oscillator assemblies

a) base mounted diode
b) side mounted diode

In addition to the tests reported on the attached data sheets, some additional frequency stability tests were carried out on these circuits. One of these tests involved operating the circuit into a 1.5:1 VSWR of various phases. It was found that the maximum frequency shift which occurred due to changing the phase of this VSWR was 4 MHz or 0.5%.

Another test was made in which the frequency of oscillation was determined immediately after turn-on of the oscillator and at various time intervals of up to two hours thereafter. The maximum frequency drift that was detected during this period of time was 1.0 MHz. However, it is felt that this is within the limits of the measurement technique that was used, and it may have been a drift in test equipment that was measured rather than the drift of the actual operating frequency of the circuit itself.

HUGHES

ELECTRON DYNAMICS DIVISION

TEST DATA SHEET

DIODE IN CIRCUIT MODEL NO. 44007H-001 SERIAL NO. 001

'EC NO. DPB128775	PART NO. B128775-001	DATA SHEET NO. DSB128775	REV. A
'ALITY 10/7/75	LOT NO. MWA971 / MODEL NO. T0502 SH	EFFECTIVITY - SAMPLE TESTS	Page 2 of 5

DATA

DIODE S/N	BV @IR=5 mA Min 185 Max 255 (Vdc)	V_F @IF= 100 mA Max: 1.5 Vdc (Vdc)	I_R @V=.5Bv Max:10 (µA)	C_{TO} Min:16 Max:40 (pF)	Du Min:1.0 (%)	t_p Min:200 (nS)	t_r Max:40 (nS)	t_f Max:40 (nS)	t_j Max:10 (nS)	Fo Min:0.75 Max:0.85 (GHz)	V_{OP} (Vdc)	I_{OP} (A)	Po Min: 3 (W)	po Min:300 (W)	n Min:25 (%)
106	220	.94	<1	23.5	1.0	200	8	10	0	.780	125	9.6	3.00	300	25

TESTED BY Btt DATE 12-16-75 TRAPATT DIODE (UHF) SAMPLE TESTS

HUGHES **ELECTRON DYNAMICS DIVISION**

TEST DATA SHEET

DIODE IN CIRCUIT MODEL NO. 44007H-002 SERIAL NO. 001

EC NO. DPB128775	PART NO. B128775-001	DATA SHEET NO. DSB128775	REV. A
ALITY [illegible] 10/31/75	LOT NO. HWA980	MODEL NO. T0502 SH	EFFECTIVITY - SAMPLE TESTS

DATA

DIODE S/N	BV @IR=5 mA Min 185 Max 255 (Vdc)	V_F @IF= 100 mA Max: 1.5 Vdc (Vdc)	I_R @V=.5Bv Max:10 (µA)	C_{TO} Min:16 Max:40 (pF)	Du Min:1.0 (%)	t_p Min:200 (nS)	t_r Max:40 (nS)	t_f Max:40 (nS)	t_j Max:10 (nS)	Fo Min: 0.75 Max: 0.85 (GHz)	V_{OP} (Vdc)	I_{OP} (A)	Po Min: 3 (W)	po Min:300 (W)	η Min:25 (%)
107	200	.81	<1	30.4	1.0	200	10	15	0	.785	120	9.6	3.02	302	26

TESTED BY BT DATE 12-16-75 TRAPATT DIODE (UHF) SAMPLE TESTS

3.2 4 GHz Oscillator Circuit Engineering Samples

Two 4.0 GHz engineering sample circuit assemblies were prepared for delivery on this contract. The circuits are shown in Figure 2. These circuits are relatively standard coaxial circuits with tuning slugs. In addition to the tuning slugs, a half wavelength transformer is used on the center conductor near the diode. This is used to provide the appropriate impedance transformation from the 50 ohm circuit to the low impedance TRAPATT device. A detailed assembly drawing of the circuit was furnished in the Tenth Quarterly Report.

3.2.1 Discussion of Test Results

The circuits described above were assembled and tuned in such a way as to yield nominally 50 Watts of RF power at 4 GHz in a 200 nanosecond pulse and 1% duty cycle. Detailed data taken on these circuits are shown in the data sheets on pages 25 and 26. As can be seen from these data sheets, the performance of the circuits are well within the specifications of the contract.

In addition to the tests reported on the attached data sheets, additional frequency stability tests were carried out on these circuits. It was found that operation of the circuit into a mismatch of 1.5:1 VSWR produced a maximum frequency shift of 20 MHz or 0.5%.

Another test was made in which the frequency of oscillation was measured immediately after turn-on of the oscillator and at various time intervals of up to two hours thereafter. The maximum frequency drift that was detected during this period of time was 2.0 MHz. As in the case of the UHF tests mentioned in the last section, it is felt that this is within

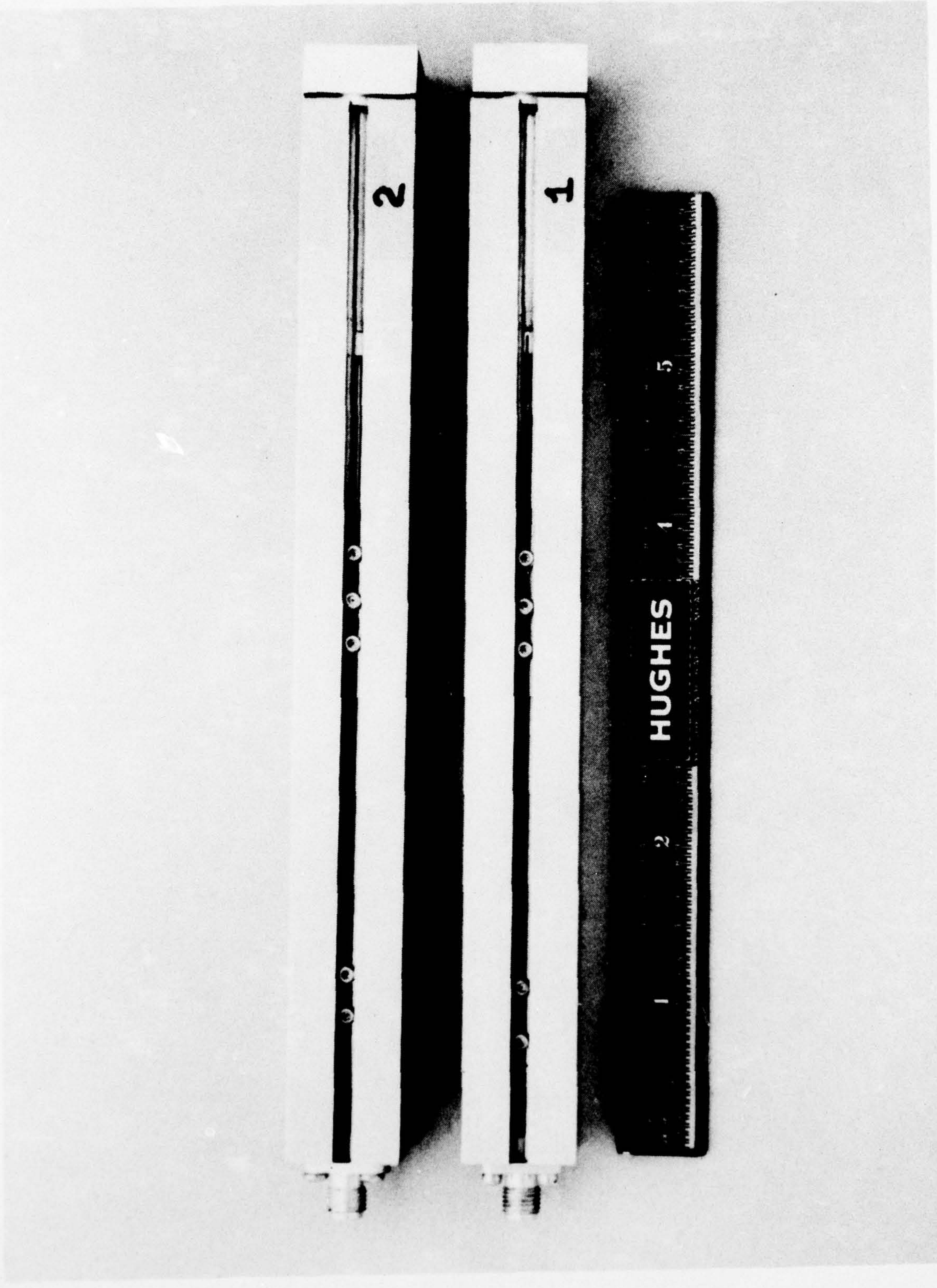


Figure 2. S-band oscillator assemblies

the limits of the measurement technique that was used. Most or all of this drift could be in the test equipment and the actual shift in frequency of the circuit itself could well be much less than this number.

HUGHES ELECTRON DYNAMICS DIVISION

TEST DATA SHEET

DIODE IN CIRCUIT MODEL NO. 44008H SERIAL NO. 002

EC NO. DPB128774	PART NO. B128774-001	DATA SHEET NO. DSB128774	REV. A
ALITY RaJeffers 10/7/75	LOT NO. MWA994	MODEL NO. T0505 PH	EFFECTIVITY - SAMPLE TESTS / Page 2 of 5

DATA

DIODE S/N	BV @IR=5mA Min 80 Max 110 (Vdc)	V_F @IF= 100 mA Max: 1.7 Vdc (Vdc)	I_R @V=.5BV Max:10 (µA)	C_{TO} Min: 5 Max:13 (pF)	Du Min 2.0 (%)	t_p Min:200 (nS)	t_r Max:40 (nS)	t_f Max:40 (nS)	t_j Max:10 (nS)	Fo Min:3.9 Max:4.1 (GHz)	V_{OP} (Vdc)	I_{OP} (A)	Po Min: 1 (W)	po Min:50 (W)	η Min 15 (%)
109	93.1	.96	<1	5.2	2.0	200	30	15	10	4.03	64	4.6	1.00	50	17

TESTED BY BTT DATE 12-16-75 TRAPATT DIODE (S) SAMPLE TESTS

HUGHES ELECTRON DYNAMICS DIVISION

TEST DATA SHEET

DIODE IN CIRCUIT MODEL NO. 44008H SERIAL NO. 001

EC NO. DPB128774	PART NO. B128774-001	DATA SHEET NO. DSB128774	REV. A
ALITY RaJeffers 10/7/75	LOT NO. HWA(S)994	MODEL NO. T0503 PH	EFFECTIVITY - SAMPLE TESTS	Page 2 of 5

DATA

DIODE S/N	BV @IR=5mA Min 80 Max 110 (Vdc)	V_F @IF= 100 mA Max: 1.7 Vdc (Vdc)	I_R @V=.53v Max:10 (μA)	C_{TO} Min: 5 Max:13 (pF)	Du Min:2.0 (%)	tp Min:200 (nS)	tr Max:40 (nS)	tf Max:40 (nS)	t_j Max:10 (nS)	Fo Min:3.9 Max:4.1 (GHz)	V_{OP} (Vdc)	I_{OP} (A)	Po Min: 1 (W)	po Min:50 (W)	η Min:15 (%)
108	92.6	.97	<1	6.0	2.0	200	25	15	10	3.98	65	4	1.00	50	19

TESTED BY BTT DATE 12-16-75

TRAPATT DIODE (S) SAMPLE TESTS

3.3 Pilot Run Circuits

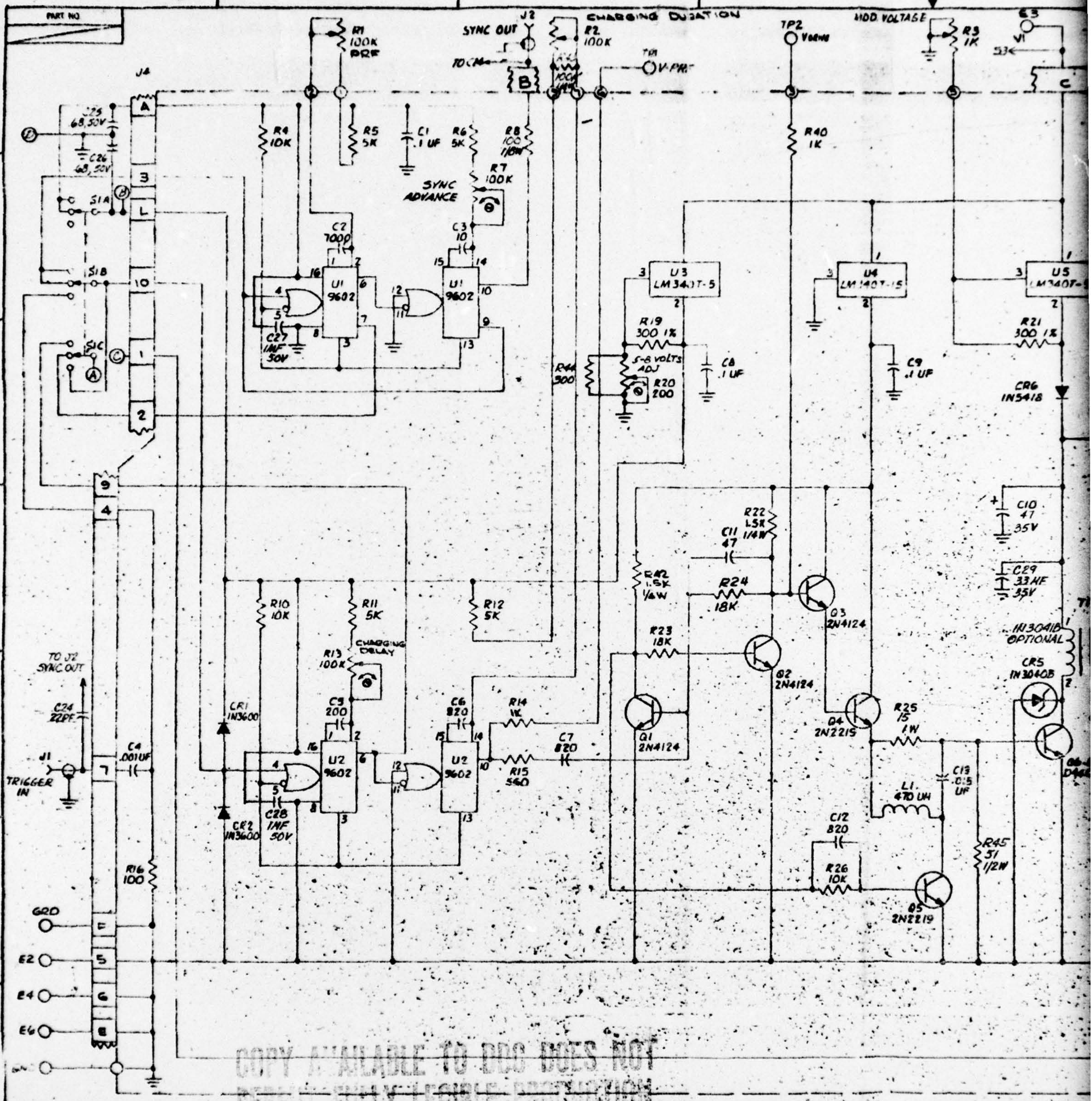
As noted in Sections 2.4 and 2.5, the 0.8 GHz and 4.0 GHz first article diodes have been delivered. Parts procurement, assembly and testing of the pilot run oscillator assemblies will begin upon receipt of approval of the first article diodes.

4.0 MODULATOR

Work on the modulators during this quarter included some minor adjustments to the pulse forming networks and documentation of the final configuration and circuitry. The pulse forming networks were adjusted to cause the TRAPATT current to slope upward slightly with time during the pulse. This slight current slope (typically five to ten percent of the initial current) compensates for warming effects in the diode junction during the pulse which tend to lower the oscillation frequency. The current slope holds the oscillation frequency more nearly constant with time during the pulse reducing "chirping" and providing a more symmetrical output spectrum.

Documentation of the final configuration of the high and low voltage modulators was accomplished this quarter. The final versions of the schematics of the high (UHF) and low (S-Band) voltage modulators are shown in Figures 3 and 4, respectively. Operation instructions will be included in a later report.

The engineering sample modulators have been finalized and will be shipped during the coming month (February). Parts procurement, assembly and testing of the pilot run modulator assemblies will begin upon receipt of approval of the first article diodes.



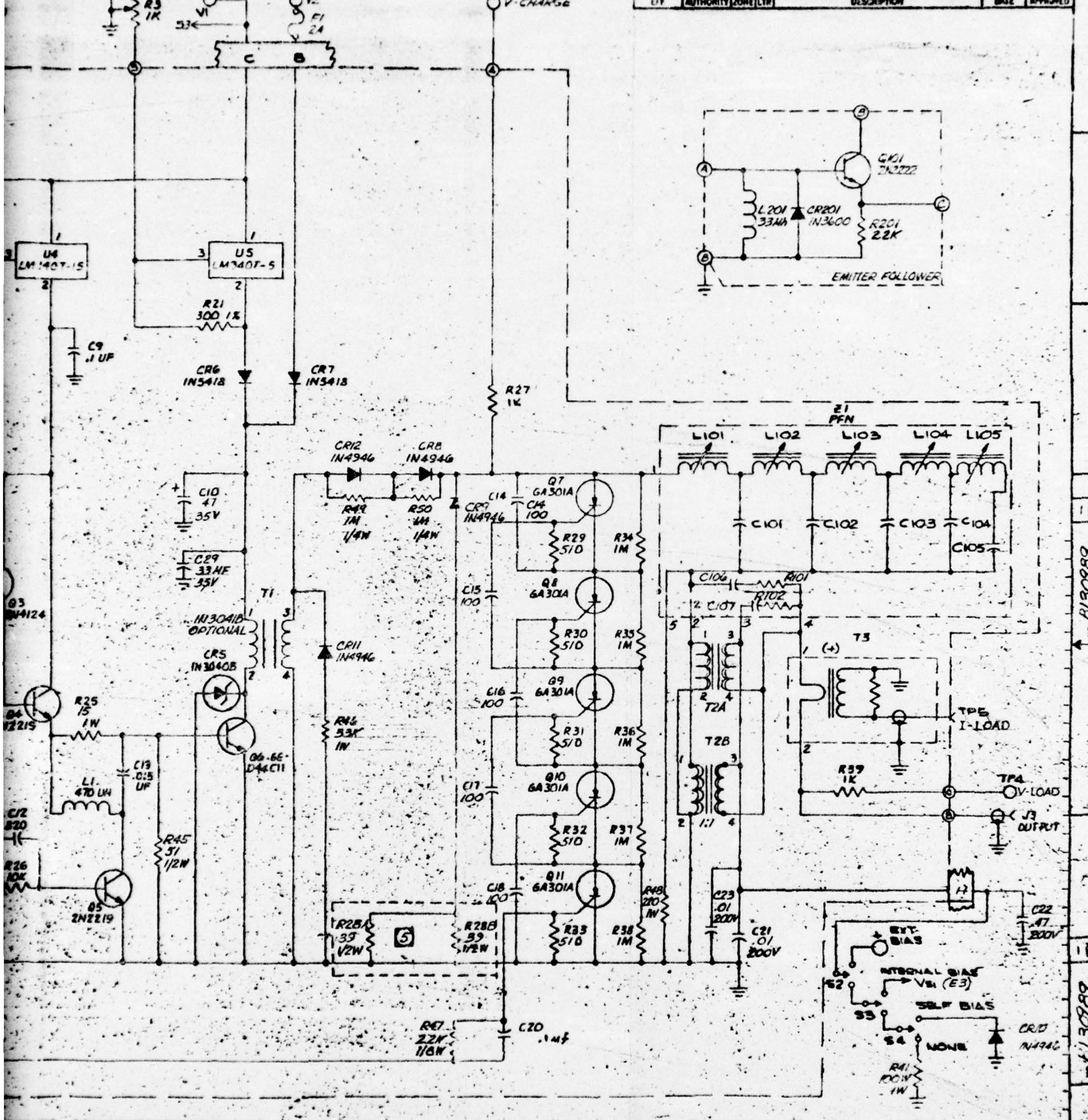
5. RESISTOR R28 MAY BE MOUNTED AS ONE 1W OR TWO 1/2W RESISTORS (R28A AND R28B)
4. CAPACITANCE VALUES ARE IN PICOFARADS.
3. RESISTANCE VALUES ARE IN OHMS ± 5%, 1/8W
2. PARTIAL REF DES ARE SHOWN. FOR COMPLETE REF DES PREFIX WITH UNIT NO. OR SUB-ASSY DES.
1. FOR ASSY DWG SEE

NOTES: UNLESS OTHERWISE SPECIFIED

	REFERENCE DESIGNATION	
	HIGHEST NO USED	NO NOT USED
Z1	C107 L-105 R-102	
FILTER FOLL	C-201 CR-201 L-201 R-201 Q-201	

REFERENCE DESIGNATION	
HIGHEST NO USED	NO. NOT USED
C29	C19
CR12	CR3
E6	
F1	
J4	
L1	
R50	R9, R17, R18, R27
Q11	
T3	
TP5	
U5	

EFF	AUTHORITY	ZONE	LTR	REVISIONS DESCRIPTION	DATE	APPROVED



REFERENCE DESIGNATION	
HIGHEST NO. USED	NO. NOT USED
C29	C19
CR12	CR3
E6	
J4	
L1	
R50	R9, R17, R18, R27
Q11	
T3	
TP5	
U5	

QTY REQD	CODE IDENT.	PART NO. OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	ZONE	FIND NO.

PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES .XXX ± .005 .XX ± .02 ANGLES ± 0° 30' FINISH 63/ EDGES & CORNERS .010 R MAX

MATERIAL

NEXT ASSY | USED ON

APPLICATION

DR R. Magee DATE 2-27-76

CHK

APPD

HUGHES

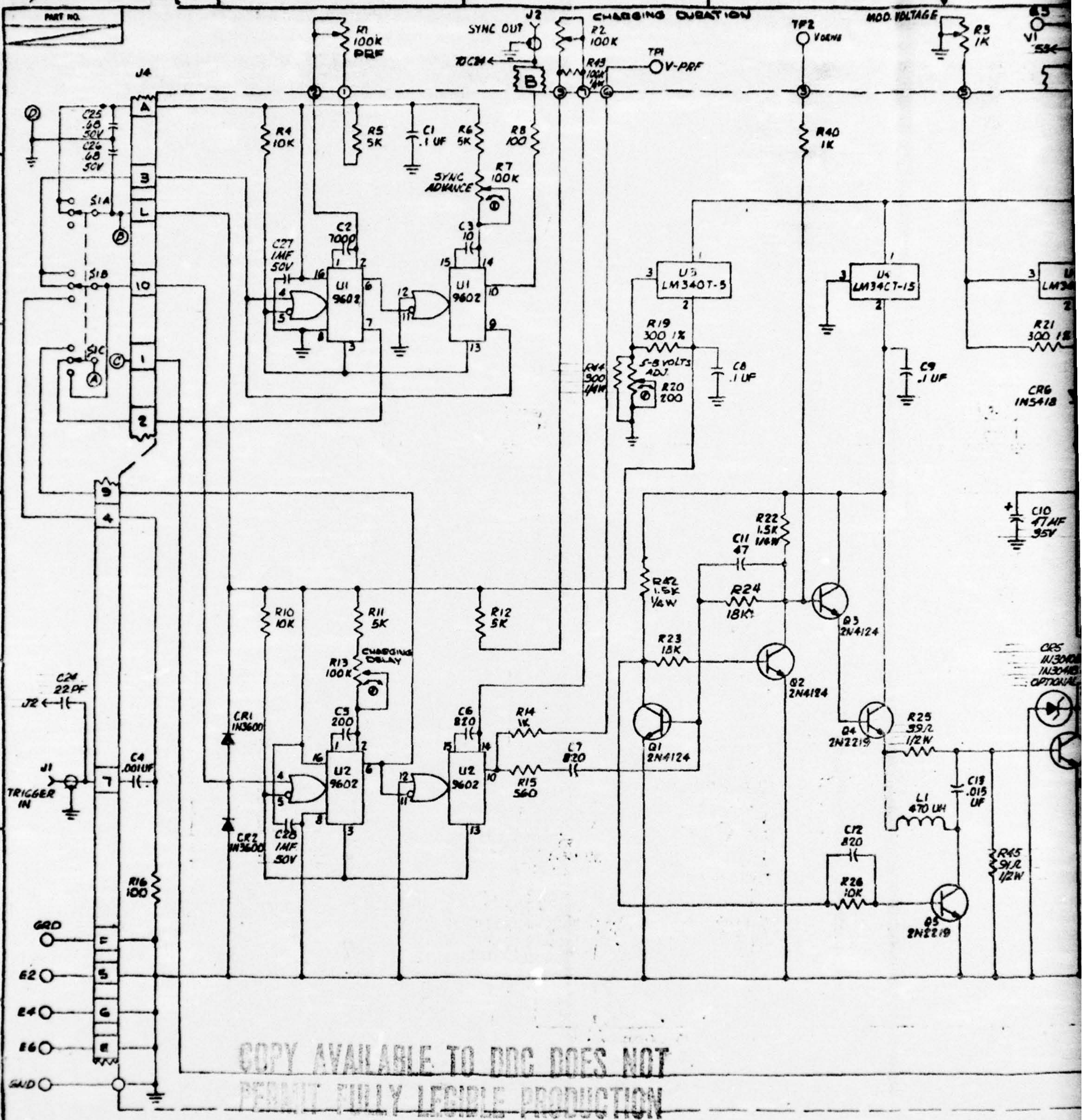
HUGHES AIRCRAFT COMPANY ELECTRON DYNAMICS DIVISION TORRANCE, CALIF. 90509

UHF-HIGH VOLTAGE UNIT TRAPATT PFM MODULATOR SCHEMATIC DIAGRAM MODEL 170 44499H

SIZE	CODE IDENT NO.	DRAWING NO.	REV
F	73293	B130989	–

SCALE — SHEET

2

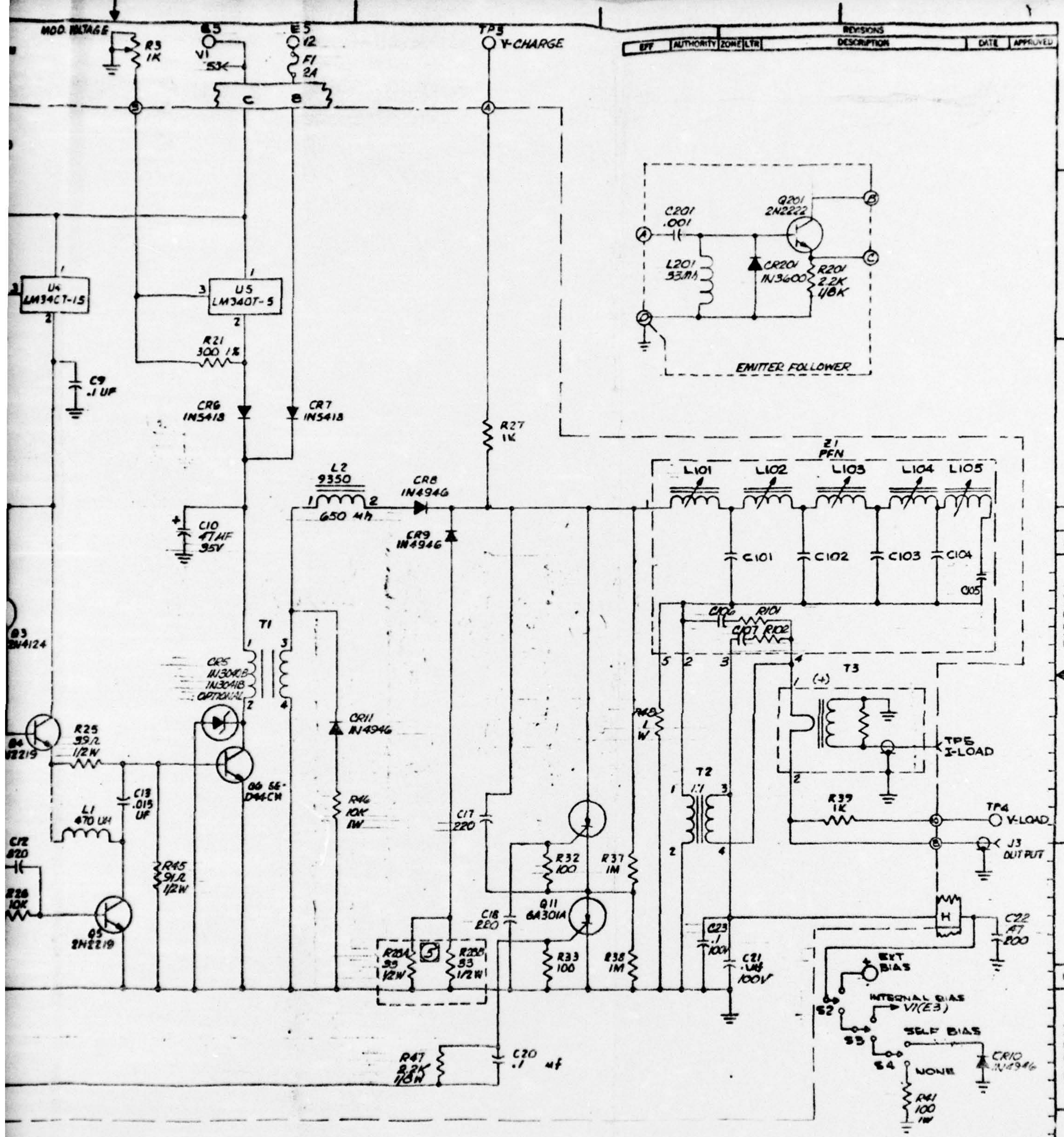


5. RESISTOR R28 MAY BE MOUNTED AS ONE 1W OR TWO 1/2W RESISTORS (R28A AND R28B)
4. CAPACITANCE VALUES ARE IN PICOFARADS.
3. RESISTANCE VALUES ARE IN OHMS ± 5%, 1/8W.
2. PARTIAL REF DES ARE SHOWN. FOR COMPLETE REF DES PREFIX WITH UNIT NO. OR SUB-ASSY DES.
1. FOR ASSY DWG SEE

NOTES: UNLESS OTHERWISE SPECIFIED

	REFERENCE DESIGNATION	
	HIGHEST NO. USED	NO. NOT USED
Z1	C-107 L-105 R-102	
EMITTER FOLLOWER	C 201 CR201 L 201 R201 Q201	

REFERENCE DESIGNATION	
HIGHEST NO. USED	NO. NOT USED
C28	C14, C15, C16,
CR11	CR3
E6	
J4	
L2	
F1	
R48	R9, R17-18, R2
	R34-36
Q11	Q7-9
T3	
TP5	
U5	



REVISIONS						
EFF	AUTHORITY	ZONE	LTR	DESCRIPTION	DATE	APPROVED

REFERENCE DESIGNATION	
HIGHEST NO. USED	NO. NOT USED
C28	C14, C15, C16, C19
CR11	CR3
E6	
J4	
L2	
F1	
R48	R9, R17-18, R29-31, R34-36
Q11	Q7-9
T3	
TP5	
U5	

QTY REQD	CODE IDENT	PART NO. OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	ZONE	FIND NO

PARTS LIST

NEXT ASSY | USED ON

APPLICATION

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES XXX ±.005 XX ±.02 ANGLES ±0° 30' FINISH 63 EDGES & CORNERS .010 R MAX

MATERIAL

DR | DATE

CHK

APPD

HUGHES

HUGHES AIRCRAFT COMPANY
ELECTRON DYNAMICS DIVISION
TORRANCE, CALIF 90509

LOW VOLTAGE(S-BAND) UNIT
TRAPATT PFM MODULATOR
SCHEMATIC DIAGRAM
MODEL 44500H

SIZE	CODE IDENT NO.	DRAWING NO.	REV
F	73293	B125161	-

SCALE — | SHEET

2

5.0 CONCLUSION

The engineering sample diodes have been tested to determine compliance with all specifications given in Hughes Specifications Nos. DPB 128775 and 774. This includes among other things testing for power, frequency, efficiency, pulse shape characteristics and temperature performance. 100% of the diodes tested passed all tests to which they were subjected. There were no failures of any type. On this basis it is concluded that all diodes manufactured according to the criteria set up for these diodes will meet the above mentioned specifications.

The only difficulty encountered in these tests related to the laboratory power supply used for the testing. It was found that this equipment was adequate for the low duty cycle testing. However, a significant degradation in wave form occurred as the duty-cycle was increased. It was determined that this is due to an inadequacy in the power supply modulator. As a result, there was some degradation in pulse shape characteristics when going to full duty cycle. At this point in time there is no obvious solution to this problem, and since it was possible to obtain diode performance per specification, no recommendation is made for modification.

Additionally, the first article diodes in both UHF and S-Band have been tested and found to be within specification. On the basis of the results for both engineering sample and first article diodes it is recommended that the manufacture of pilot run diodes should proceed.

Engineering test sample oscillator assemblies and modulator assemblies for both UHF and S-Band have been tested and found to perform satisfactorily. It is recommended that manufacture and assembly of pilot run oscillator and modulator assemblies should proceed.